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Failure To Rescue, What Can Be Done To Prevent It?

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Abstract

Introduction: Failure to Rescue (FTR) is the failure to prevent a patient's death after a complication. It measures the ability of a hospital to prevent the death of patients who develop one or more complication that was not present at the time of admission. Therefore, the aim of this study is to review the factors that contribute to FTR, and the measures and strategies that can be applied to prevent the FTR events, in order to discuss the best way to improve patient outcomes in the hospital setting. **Methods:** A search was conducted on PUBMED retrieving a total of 464 articles. A review of the selected articles' bibliography was conducted to find other relevant articles. Sixty studies were reviewed in this paper. **Results:** Patient factors as increasing age, comorbidities and frailty increase the risk of FTR, as well as an increasing number of complications. Several hospital factors, nursing care, and microsystem also influence FTR. Some track and Trigger Systems (TTS) and Early Warning Scores (EWS) have been shown to predict clinical deterioration. On the other hand, machine learning systems have outperformed EWS. Rapid response teams have become the standard approach to delivery and escalation of care, and cognitive aids and crisis checklists also have potential to help reduce FTR. **Conclusion:** Patient and hospital factors are often non-modifiable; thus, microsystem factors could be a target for improvement. Creating clinical pathways can improve surveillance, and communication tools like SBAR can help relay information. EWS, machine learning models and continuous monitoring are strategies that can help detect clinical deterioration. In the efferent limb rapid response teams have shown to reduce FTR.

Keywords: Failure to Rescue, Early Warning Score, Rapid Response Team, Continuous Monitoring.

Abbreviations: CVSM-Continuous Vital Sign Monitoring, EWS-Early Warning Score, FTR-Failure to Rescue, ICU-Intensive Care Unit, MET-Medical Emergency Team, MEWS-Modified Early Warning Score, NEWS-National Early Warning Score, RRT-Rapid Response Team, SBAR-Situation Background Assessment and Recommendation, TTS-Track and Trigger System.

Introduction

Failure to Rescue (FTR) was first described in 1992 by Silber et al as the failure to prevent death after a complication in the surgical patients. According to Silber et al, there were only 2 formal attempts to develop a medical FTR metric before their own in 2018 [1-4]. It measures the ability of a hospital to prevent the death of patients who develop one or more complication that was not present at the time of admission by identifying and successfully managing it [4-6].

Failure to rescue is an important metric to measure the quality of care of an hospital and it is different from the in-patient mortality, which describes all patients deaths during hospitalization [5,7,8]. On the other hand, FTR rate is calculated using the number of patients with a complication as a denominator and as a numerator the number of patients that died following a complication [8].

The definition of FTR has evolved with time and various definitions have been posted in the literature, with different specific complications for each one, based on the subpopulation it was applied to [2,4,8]. In 2002, Needleman et al described a version that was nursing sensitive, with complications that related to nursing interventions (pneumonia, shock, gastrointestinal bleed, cardiac arrest, sepsis and deep venous thrombosis), and was later termed as FTR-N by Silber [8,9]. In 2007 the Agency for Healthcare Research and Quality used this last definition, adding one other complication (renal failure), as a patient safety indicator to measure and grade hospital care and was labeled as FTR-A [2,10]. Having various versions of this metric, created for different subpopulations, although it can alter the calculation of the FTR based on which definition is used, can be helpful to evaluate the occurrence of this event in different settings, with different particularities, more accurately [8]. Even so, having a common definition would serve to use and measure it as a common metric for all hospitals [1].

Failure to rescue is a multifaceted and complex problem, with several risk factors contributing to it [2]. Those factors can be divided into macro system factors such as hospital type (academic and critical access), size and volume, technology, resources or staffing ratio and microsystem factors such as intensive care units and rapid response teams composition, hospital culture on teamwork and communication or psychological safety [3,8,11,12]. Furthermore, there are also patient factors that can have an impact on failure to rescue, since

complications are primarily associated with their characteristics [2,3,8]. Increased age and frailty have shown to contribute to failure to rescue, also preexisting comorbidities and the condition of admission, as well as the performance status at the time of a surgery, can influence the outcome [3,8,13].

In the macro system factors, high-volume hospitals are associated with lower rates of FTR, although they are not associated with lower complication rates8, and so was surgeon volume [3,8,4,14]. These hospitals are usually teaching hospitals, although the teaching status itself was not clearly associated to a reduction on the FTR rate [14]. The hospitals with high technology were also related to lower FTR rates [1].

The staffing of the hospital also plays a role in the FTR rate8. It is common in hospitals to have decreased staffing during the night or at weekends, particularly in unmonitored units, leading to treatment delays and worse outcomes [8,15]. Specifically, the nursing staff and nurse-patient ratios have been one of the most consistent factors associated with FTR [8]. Also, the nurse's education has been shown to have an impact on FTR, hospitals with higher proportions of nurses with bachelor's degree or higher have a lower FTR rate [10,16].

When it comes to the microsystem factors, closed Intensive Care Unit (ICU) settings with a larger proportion of certified intensivists have also shown to reduce FTR [1,17]. Also in the microsystem factors, the hospital culture on teamwork and communication, as well as the psychological safety of the team contribute to better outcomes, including FTR [14]. Communication is a very important factor in the quality of care and the nurses and junior physicians must feel comfortable communicating with senior physicians about their concerns [14]. It is important that the healthcare environment culture supports those in direct contact with the patients to provide opportunities for better and timely care to be provided3. Teamwork also plays a major role in responding well to complications, by taking advantage of the cognitive diversity of the team members and abolishing traditional hierarchies [12]. Psychological safety is important to reassure confidence to the care providers to speak up, report mistakes, question others and express concerns to higher hierarchic members without fear of any adverse effect [12].

The failure to rescue events can be broken down into a progression from a complication that can be either identified and communicated by an afferent limb to the efferent limb that provides the escalation of care the patient needs, or that can progress to death due to a failure at any point in this circuit [2,8]. The nursing factors and attributes focus mainly on the afferent limb, and the physician factors are mostly on the efferent limb [2]. This concept is the basis of the rapid response systems, whose principles are early recognition and prompt and appropriate intervention, where the afferent limb refers to the measures that focus on identifying the deteriorating patient, and the efferent limb refers to the interventions to rescue the patient [18].

Patients who require ICU admission from the ward can have changes in measurable clinical variables, like vital signs, up to 48 hours before transfer20. The identification of this changes and thus patient deterioration is part of the afferent limb [18].

There are systems that help nurses to know when to escalate care and also detect changes prior to deterioration, such as early warning scores (EWS), also known as Track and Trigger Systems (TTS) [8,10,19,20]. There are various types of these systems that can be divided into single parameter, multiple parameter or aggregate weighted systems. The single parameter systems rely on any single deviation of vital signs, laboratory values, and urine output or oxygen saturation to trigger a response. Multiple parameter systems are expanded versions of the single parameter ones, using a combination of abnormal signs to trigger a response. The aggregate weighted systems assign points to the degree of deviation of individual physiological variables, combining them to a score, which has thresholds for triggering [19]. In addition, many systems include the facility for triggering on a subjective basis, recognizing the importance of clinical intuition in patient assessment [18].

Another strategy to improve the detection of patients that can be deteriorating is the use of continuous monitoring in general wards, that can provide dynamic information about the patterns of the vital signs of the patient, and there can also be achieved an automation of the calculation of scores to trigger an escalation of care [20-24]. These automated programs also can be used in the ICU context, where is already continuous monitoring to help prevent FTR events in this setting [25]. In this setting, an implementation of telemedicine ICU nursing can also help improve the outcomes of the patients [26,27].

The efferent limb is just as important as the afferent limb, as it is the response to the trigger and initiates the escalation of care [19]. For this, the implementation of Rapid Response Teams (RRT) or Medical Emergency Teams (MET) arose as a method to provide care to patients that were deteriorating or at risk of deteriorating at their bedside [28]. The continuation of the pathway for some patients is the ICU setting, where, as said before, FTR can also occur [8]. The development of crisis-checklists can also help the team that is usually with the patient manage an emergency while escalation to a RRT occurs [29].

The afferent and efferent limbs work as a continuous pathway, being both essential for the patient safety and prevention of FTR events [2,3]. In this paper, the aim is to review the factors that contribute to FTR, and the measures and strategies that can be applied to prevent the FTR events, both in detecting and in the process of escalation of care, in order to discuss the best way to improve patient outcomes in the hospital setting.

Materials and Methods

A search was conducted on PUBMED using the following keyword combinations: "failure to rescue health care statistics and numerical data"; "failure to rescue quality"; "failure to rescue rates"; "failure to rescue health care"; "failure to rescue" AND rapid response system; "medical care" AND "failure to rescue"; "failure to rescue" AND deteriorating patient; "failure to rescue" AND general ward; rapid response team AND "failure to rescue"; hospital staffing AND "failure to rescue"; early warning score* AND "failure to rescue"; medical emergency team* AND "failure to rescue"; track and trigger AND "failure to rescue"; "failure to rescue" AND continuous monitoring; "failure to rescue" AND telemedicine; concept OR definition AND "failure to rescue". A review of the bibliography of the articles selected was conducted to find other relevant articles.

A total of 464 articles were found using the mentioned keywords. 60 articles were selected to this revision. Inclusion criteria include English language publication, review articles, systematic reviews, retrospective or prospective studies, quantitative and qualitative studies. Exclusion criteria include articles published in other language than English, studies about pediatric or obstetric population, articles where FTR was not the main or one of the main topics, articles comparing surgical procedures or their outcomes, studies about specific clinical or surgical interventions. Timeline: articles were included from the search since 2015 till 2020. 1 article cited in the reviewed studies was included.

Results

In a systematic review by Johnston et al in 2015, the values of FTR in the articles reviewed varied from 0,03% to 16,9%. Studies suggest that, in the United States, between 22 000 to 200 000 avoidable deaths occur in hospitals per year [5,30].

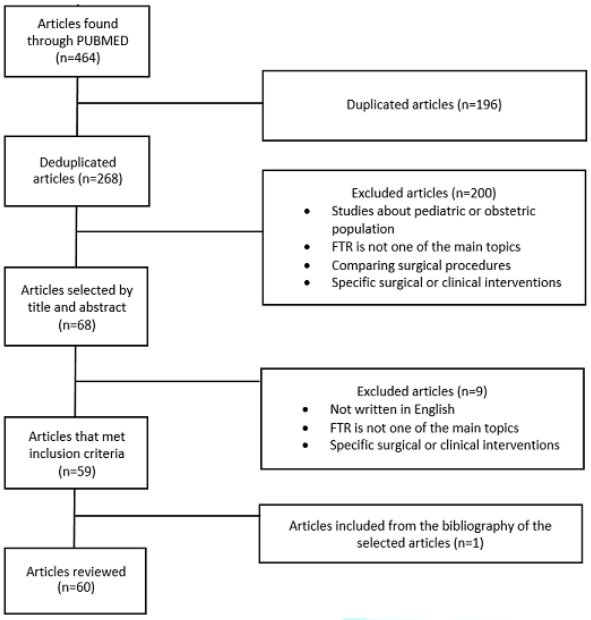

Figure 1: Inclusion/exclusion criteria for articles inclusion in the review.

Patient factors, such as increasing age, increase the risk of FTR. In a study of trauma population, the risk of FTR increased in a stepwise fashion with increasing age, reaching almost 28-folder higher risk for patients with over 90 years old, and the risk increased significantly from 66 years and higher. The FTR patients in this study also had more commonly comorbidities such as cardiac disease and bleeding disorders. Increased age is also associated with the development of more complications [31]. In another study, contributors to both development of adverse events and FTR were 70 or more years of age, renal disease, and penetrating mechanism of injury, decreased Coma Glasgow Score, and increased Injury Severity Score [32].

Frailty has also been associated with higher risk of FTR [1,13]. There is an association with increasing frailty and number of complications, and also FTR. Although the increase in FTR can be mediated by the increasing number of complications, frailty increases the occurrence of FTR by itself. This association is present not only in high-risk surgeries, but also in lower risk operations, although in a smaller scale [13].

Despites an increase in the number of complications being related to a higher risk of FTR, the type of complication can also have an impact [31,33-35]. In addition to age, Injury Severity Score, Charlson Comorbidity Index and number of complications, complications like sepsis, pneumonia, acute respiratory distress syndrome and cardiovascular complications independently increased the risk of FTR [35]. Moreover, the impact of having a respiratory and an infectious complication combined is synergistic [34].

Hospital performance is another factor that is associated with FTR. Hospitals with higher performance have lower FTR rates [36-38]. In a cohort using the Japan Trauma Data Bank, hospitals with higher performance had fewer complications and lower FTR rates, whereas high-mortality hospitals had both more complications and higher FTR rates, indicating that in trauma patients, complications and rescue from a complication can be related to better performance in these hospitals [36]. In a study of patients undergoing non-cardiac surgery in Veterans Affair hospitals the FTR rate was also higher in the high-mortality hospitals, while the complication rates were not statistically different [37]. Sheetz et al also found a correlation between high-mortality hospitals and higher FTR rates in a study to determine the effect of hospital characteristics on failure to rescue after high-risk surgery [38].

Hospital volume was also associated as a factor that affects FTR rates in several articles [3,7,14,30,35,39]. In a study using data from 27 countries from patients undergoing surgery in low, middle and high-income countries, hospitals were ranked by volume of surgical procedures and by complication rates. Hospitals with higher volume had lower FTR rates than lower volume ones, and the hospitals with the highest complication rates were not the ones with highest FTR rates [7]. Level 1 trauma centers were also associated with lower FTR rates35. Indeed, according to Slim et al, "studies of hospital and surgeon volumes found a statistically significant reduction of 29-77% of FTR".

Hospital factors such as teaching status, high hospital technology, and increasing nurse-to-patient ratio and presence of an ICU larger than 20 beds influenced FTR rates, offering a survival advantage for patients undergoing major surgery [38]. Regarding trauma patients, bed size over 600 and teaching status, besides being a level 1 center, were independently associated with lower FTR rates [35]. In a study that analyzed FTR in a medical population after acute myocardial infarction, major teaching hospitals displayed 19% lower odds of FTR than non-teaching hospitals, and hospitals with a good nursing mix and staffing, cardiac technology and teaching status displayed 33% lower odds of FTR than hospitals without these characteristics4. The teaching intensity has also been related with better FTR rates [10]. The participation of residents in surgical procedures has also been related with lower FTR rates, especially in cardiothoracic procedures where the residents were more likely to be senior-level residents [33].

Failure to rescue is an outcome that is highly sensitive to nursing care [10]. Implementation in the United States of minimum nurse staffing levels has reduced the FTR rates and in the United Kingdom its use as a nurse sensitive quality indicator has been supported by lower FTR rates in hospitals with better staffing by lower patient-nurse ratios [10]. An increasing of nurse staffing by 10% reduced FTR rates by 4% and hospitals with higher proportions of bachelor's degree also had reduced rates of FTR [10,16]. In addition to the staffing levels, when nursing surveillance is performed 12 or more times a day, compared with less than 12 times a day, there is a significant decrease in FTR [10].

In a qualitative study, abilities of enrolled and registered nurses in recognizing clinical deterioration were found to be influenced by their knowledge of patients, past experiences with clinical deterioration, patient assessment, workload and staffing levels. Furthermore, having an adequate number of experienced nurses on each shift was considered essential, as well as having a supportive ward culture, where nurses have no fear to consult each other or seek for help. Ineffective nursing relationships between enrolled and registered nurses from suboptimal communication and teamwork and ineffective delegation skills can have undesirable consequences for deteriorating patients [40].

Higher levels of staffing are associated with reduction in FTR, both in surgical and medical patients, although the association is not as strong in medical patients [9]. Furthermore, a greater number of hours of nursing care is associated with a reduction in FTR rates [3,9]. In addition, favorable nursing environments, with effective communication between nurses and physicians have lower risk of FTR [3,9,41]. The teamwork between physicians and nurses has even more effect when there is better nurse staffing and education [41]. Nurse autonomy is also associated with a reduction in FTR, and higher education of nurses is associated with an enhanced predisposition to exercise their professional judgment in decision making [42].

There have been developed many track and trigger systems. Single parameter systems shown reductions in patient adverse outcomes in small, single center and nonrandomized studies, both in medical and

surgical wards, however a large randomized control trial of such a system did not show these benefits [19].

The most reviewed and validated early warning scores are the aggregate weighted scoring systems [19]. These are popular in the United Kingdom and allow a graded response depending on the total score [18]. The NEWS (National Early Warning Score), published by the Royal College of Physicians of London in 2012, has been shown to be a good predictor of deterioration leading to ICU admission or death and to be superior to 33 aggregate weighted scoring systems for detecting mortality, cardiac arrest and anticipated ICU transfers [18,19,43]. Also, many track and trigger systems include the possibility to trigger escalation on a subjective basis, when staff, family or patient were worried. Analyses of these subjective activations suggests most were due to respiratory observations, where deterioration was too subtle to trigger on a physiologic basis [18].

The Modified Early Warning Score (MEWS) is another aggregate weighted scoring system, which have been reported to have a positive relationship with earlier detection of clinical deterioration, however it has limitations. If one of the physiologic parameters is unassessed, ignored, or unreported the patient remains at risk of deterioration, or in comparison, inappropriate trigger scores can activate unnecessary calls, which decrease this tool's effectiveness and increases workloads of bedside nurses, physicians, and rapid response team members [44].

Although these addictive scores like the NEWS or the MEWS are easy to apply and interpret, their accuracy is precluded by using static variable thresholds for a small number of parameters [20]. Also, recording the vital signs on a paper chart has significant potential for inaccuracy, with studies demonstrating that almost 20% of NEWS scores were calculated incorrectly [19].

Prediction tools from electronic medical records have also been used to predict a patient's probability of clinical deterioration up to 2 to 48 hours in advance, and can decrease false alarms by 50% [19]. The electronic Cardiac Arrest Risk Triage that was developed using regression coefficients outperformed MEWS and NEWS in a retrospective analysis of postoperative surgical patients [20]. In a study by Kia et al a machine learning model of patient deterioration was developed that included demographics, vitals, lab results and physical exam findings that had significantly better performance than MEWS and could warn about patient deterioration 6 hours prior to the event and help clinicians make timely interventions, using not only "point in time" measurements, but also prior data and trends.

Continuous monitoring of patients can also improve the early detection of patient's deterioration [20,22]. In a 2016 study, it was demonstrated that continuous multi-parameter monitoring could be performed on medical and surgical units with a small and appropriate level of audible alerts, and that it may have initiated nurse interventions that prevented failure to rescue events. On other study, 2 types of continuous monitoring technologies were studied, one not necessitating direct patient contact and another one direct patient contact, found that both accurately predicted patient deterioration [22,45]. Another technology described in another study was the cVSM (continuous Vital Sign Monitoring), which was different than simply telemetry monitoring, that sounds an alarm anytime a parameter breaches a threshold, this has programed delays that allow vital-signs to self-correct to prevent unnecessary alarms, that can lead to staff distraction and alarm fatigue. Nurses were able to identify signs of deterioration early and intervene more quickly, improving patients outcomes. The incidence of FTR using this technology declined to zero and the complication rate decreased from 22% to 5.9% [20].

Another strategy that can improve the afferent limb is the telemedicine ICU implementation, whose nursing interventions have been studied by Williams et al, identifying that consultation, education and mentoring by the nurses in this setting helped reduce FTR. On the contrary, physiological interventions were associated with more cases of FTR, indicating likely late interventions from the tele-ICU or the ICU team.

In the efferent arm, rapid response teams and medical emergency teams have become the standard approach to prevent FTR [18]. In many European countries, these teams are represented by ambulance resuscitation teams [14]. There are often variations of the composition of the team, and while earlier studies indicated that the team's structure was not related with the outcomes, more recent evidence suggests that intensivists on RRTs are predictors of better performance and can reduce FTR [10].

Rapid response teams or medical emergency teams are often presented as a factor in hospitals with lower FTR rates [1,16]. In a study that measured the outcomes after the implementation of a rapid response system on a large healthcare jurisdiction, it was found that cardiopulmonary arrests, and related deaths, mortality and FTR decreased but at the same rate as before the implementation; however, the mortality in the low-mortality diagnostic-related group subpopulation decreased significantly. Other articles also report that RRTs have reduced hospital mortality, unplanned ICU transfers and unexpected cardiac arrests [19,27,46,47].

The use of cognitive aids can also help the team in the critical management of the deteriorating patient, with one study in a simulation environment reporting a decreasing in the percentage of omitted critical management steps of 70% [48]. Besides cognitive aids, the use of checklists structuring responses to clinical deterioration has potential to improve patient care and outcomes, since the first responders on the efferent limb are frequently an assembly of available providers of care with limited experience in managing emergency situations [28].

Discussion

Besides the variation of FTR observed in various studies, it's relation with the mortality rate can also be different depending on the care setting that is being analyzed [14,49]. It depends on the precedence of deaths occurring in the studied setting, with precedence being a complication occurring after the admission. In the trauma setting precedence is lower than 30% [49,50], whereas in elective surgery and emergency general surgery the precedence rate is about 85% [49]. The lower value of precedence in the trauma setting can be explained by the death of some patients due to the injury that led them to that service before any complication can occur [50].

Factors that affect FTR

Regarding patient factors that can affect FTR, age has been shown in several studies and in several healthcare settings to be associated with FTR, particularly in trauma populations [1,8,14,31,32,50,51]. Besides being associated independently with FTR, increasing age also relates with the risk of developing a cluster of complications, which also increases the risk of FTR [31]. In a trauma patients' study, Earl-Royal et al aimed to identify pre-existing conditions as risk factors for adverse events and FTR. They found that each decade above 60 years had a higher risk of developing adverse events, and that above age 70 the risk of FTR also increased. Theories linking the increasing age with increasing mortality in trauma patients relate to decreased physiological reserve, polypharmacy and frailty [32]. Some strategies to minimize the impact of complications in the geriatric population in trauma care are a multidisciplinary approach to care of these patients, with early geriatric consultation, early admission to a highly monitored setting or having availability of a trauma bed in the surgical ICU for elderly trauma patients, as well as a higher nurse-to-patient ratio for this patients, in order to recognize the potential complications early and preventing them [31].

Besides age, frailty is also associated with FTR, and some authors argue that it can be a more reliable risk factor for FTR than age itself

[1,8,13]. It is important to identify these patients, that are not necessarily all elderly, since patients in the highest strata of frailty can also be under 55 years, to increase attentiveness to them and improve FTR rates [1,3,8]. Also, prehabilitation programs have shown to be effective in reducing postoperative complications in these patients, although it has not yet been demonstrated they reduce FTR [3,13].

The comorbidities are also an important factor, since they contribute to the occurrence of complications41; 51, but also to FTR [3,14,31,32,41,50,51]. In trauma patients, the comorbidities associated with FTR are not consensual between studies, in a study the comorbidities associated with FTR were cardiac disease and bleeding disorders, whereas in another study, several comorbidities were associated with the development of complications, but only renal disease, liver disease and coagulopathy were associated with FTR, and reported that in other studies diabetes was also a risk factor for FTR [31,32].

The traditional FTR metric only accounts for one complication, and if there are multiple occurrences, only the first is counted [8,34,50]. Yet, the risk of FTR increases in a stepwise fashion with the number of complications and besides, the traditional approach may miss differences in what followed the index complication and lead to death [31,33-35]. Certain index complications have been shown to be related to an increased risk for particular secondary complications, as myocardial infarction followed by cardiac arrest, and there is significant variation between some index complications and the following secondary complications [3,34]. Secondary complications play an important role between the first complication and mortality, therefore it is important that an initial complication signals a potentially important change in the patient status and timely and appropriate treatment is initiated to reduce the risk of additional complications and mortality [3]. In a cohort of emergency general surgery, Hatchimonji et al found that among the patients who died with more than 1 complication, 82.5% had a respiratory and 77.5% had an infectious complication. Having increased attention to specific complications such as respiratory, infectious or cardiovascular complications may also be important, since these independently increase the risk for FTR [34,35].

Hospital performance, in terms of mortality, is also related to FTR, being high-mortality hospitals associated with higher FTR rates [36-38]. Massarweh et al found that there were no significant differences in complication rates across the performance quintiles of hospitals in their study, however the FTR rate was lower in better performing hospitals, suggesting that these hospitals can be associated with better management and rescue from complications.

Higher hospital volume and surgeon volume is associated in several articles with lower FTR rates, and Rosero and colleagues also found that hospitals with lower procedure volume for major abdominal surgery were associated with higher FTR rates [3,7,8,14,30,35,39]. In addition, level 1 trauma centers, which are more likely to have a higher annual volume, were associated with lower FTR rates in the Roussas et al study [35]. This may be related to the infrastructures, care protocols, both formal and informal, nursing staff being familiar with determined patient populations, procedures and complications, and the surgeons' experience with common postoperative complications that require timely attention and intervention [8]. The centralization or regionalization of care can contribute to reducing FTR, due to this relation between volume and FTR and possibly by reducing variations in practice [14,35].

Several other hospital factors have been shown in several studies, across different settings, to reduce the risk of FTR [4,10,17,33,35,38]. Hospitals with lower FTR rates tend to have more board-certified intensivists and a closed model ICU, higher rates of employing hospitalists, advanced practice providers, residents and presence of overnight coverage and use of rapid response teams, in a study by Ward and colleagues [17]. However, these factors, along with the patient factors, do not completely explain the variation of FTR between hospitals [1,8,12]. On top of that, many of these hospital factors are often not easily alterable, because of financial constraints [12].

Other factors that can help explain the occurrence of FTR are the microsystem factors, that relate to human individual factors, for example the staff behavior and attitudes, and the safety culture at the institution level, that relates to the values, beliefs, norms, and traditions of the organization [3,38,39]. These microsystem factors can act as barriers in proper escalation of care that comprises the identification of deterioration, effective communication, and an adequate response [39, 52,53]. The identification of deterioration can be negatively affected by clinical inexperience, high workload, and overconfidence, whereas communication and be impaired by hierarchical barriers, fear of criticism, a desire for independence and frequent interruptions in clinical work [39]. In a study by Smith et al, 5 microsystem characteristics were identified as being important to the rescue of surgical patients: teamwork; action taking; psychological safety; recognition; and communication. Despite emerging evidence that suggests that focusing on improving these factors may be a more prosecutable way to improve care, even in large scale interventions, there is still few data about their contribution to reduce FTR [1, 12,14,17,38,39,54].

Team resource management, that derives from crew resource management training in aviation, aims to improve the teamwork and communication in healthcare by addressing communication principles for speaking up, leadership support, teamwork, evidence-based practices, just culture and patient centeredness, and it also involves simulation training where the whole team train in simulated crisis scenarios [2,5,10]. Simulation training is a growing practice in healthcare, and has potential in help preventing FTR, by allowing to identify and review contributing factors and practice skills to prevent FTR. Additionally, teamwork strategies practiced in these trainings help nurses to see the whole picture in a determined situation, and communicate within hierarchical structures. Also, simulation sessions that are interdisciplinary help build a safety culture between disciplines, improving teamwork [2]. Besides improvements in the perception of teamwork by healthcare practitioners, improved patient outcomes have also been shown when multidisciplinary safety programs are implemented [10].

Afferent limb

The nursing care has also been consistently associated with FTR [1-3, 8-10]. A better nurse staffing has been shown to improve FTR, not only in quantity of nurses, but also in the nurses' education, being higher proportions of nurses with bachelor's degree associated with lower FTR rates [1,10,16,41]. The nursing skill mix, or the proportion of registered nurses, also has an impact on FTR, being a higher proportion also associated with a reduction in FTR [4,55]. It is important to state that the quantity of staff for itself may not be sufficient to improve patient outcomes, as demonstrated in a study by Twigg et al, where the addition of assistants to nurse care in an acute ward setting actually increased FTR, thus emphasizing the importance of quality nursing care [56]. There is also an association with increased surveillance and decreasing FTR, with more than 12 nurse assessments reducing FTR. In order to improve surveillance, creation of clinical pathways may be a strategy to implement [10].

Staffing levels, workload, past experiences with clinical deterioration and knowing a patient have been associated with the ability to recognize deterioration by nurses. A strategy that may improve the recognition of clinical deterioration is assigning nurses to care for the same group of patients on a regular basis, reducing their workload and the need to learn about the patient, and also help them develop a connection with the patients [40].

The teamwork and communication are also important in what comes to nursing care, both with registered and enrolled nurses, and also in the

nurse-physician relationship [3,9,40,41]. This last can be optimized in various ways, by implementing interactive multidisciplinary rounds, maintaining professional standards and using conflict resolution strategies [10]. Furthermore, using tools like SBAR, that stands for Situation, Background, Assessment and Recommendation, helps relay information in a structured and succinct form, and improves confidence when managing emergent situations and calling for help [2,10]. Some centers have also introduced the ISBAR that contains an Introduction to make sure that those who are participating in the handover and the patient are well identified [10].

In a study from 2016 analyzing four case scenarios, Jones and Johnstone reported that in attentional blindness – the failure to things that are in plain sight due to being unexpected – could be a salient yet overlooked human factor in FTR across critical care [57]. This study highlighted the difficulty of maintaining attention and watchfulness while repeatedly performing a task, even to expert clinicians.

There is contradictory evidence in the literature regarding the use of early warning scores, while some authors claim they are not reliable in determining those patients who will deteriorate and those who will not, and others say they have led to a reduction in preventable adverse outcomes and are well established across the globe [8,47]. Many track and trigger systems have been developed, making it hard to compare them and validate them with each other and across different hospital systems [19].

Although single parameter systems have shown reductions in patient adverse outcomes in small, single center and nonrandomized studies, both in medical and surgical wards, they were unable to show these results in a large randomized control trial [19].

Aggregate weighted scoring systems, like NEWS and MEWS, also have limitations, since the scores are usually defined manually, alarm triggers are based on empirically chosen values, and the thresholds are usually defined to capture the most clinically relevant events, which can result in non-specific alerts and false alarms generating alarm fatigue [19,58]. In addition, regarding NEWS, the response that is triggered with 3 points in any component triggers the same response as an aggregate value of 5 points, on the other hand, the latter indicates a significantly higher risk. This alarm triggering increases the workload with discrete improvements in detection of deterioration, increasing the risk of alarm fatigue and diversion of medical care from patients who could potentially have a greater need. Alternatives to improve this would be either defining more extreme values for scoring 3 points based on levels at which the risk is similar to an aggregate score of 5 or increasing the frequency of observation of patients with 3 points on a single component rather than immediately escalate care [43]. It was also hypothesized that the occurrence of a derangement was more important than its degree, and that a binary EWS, that only scores 1 or 0 could be more effective than traditional EWS, however the binary NEWS, the best performing of the binary systems, was still outperformed by the traditional EWS and although they could lead to earlier detection, providing more time for interventions, the number of early false alarms could result in latter triggers being ignored [59].

Implementing digital handheld devices for electronic charting can be a good strategy to improve the performance of TTS, since that recording vital signs on a paper chart has potential for inaccuracy and errors in calculation. These devices have shown to allow for a faster and more accurate calculation of EWS, and the automatic calculation and embedded alerts was associated with an increase in accuracy and attendance to patients with high EWS scores [19].

Electronic medical records can be used by prediction tools and automated detection programs, as machine learning models, to calculate the probability of clinical deterioration before it happens and send an alert to a clinician [19,20,25,58]. Machine learning models have shown to outperform EWS systems, as NEWS and MEWS, as they may allow for better early identification of decompensating patients [1,20,58]. Notwithstanding, these models depend on the quality and quantity of the data used to train them, and may promote a false sense of security, over-triage, or recommend ineffective or harmful treatment if the training is poorly done, and an errant model could harm a great number of patients, while clinicians errors only affect one patient at a time [20].

Continuous monitoring of vital signs can improve early detection of clinical deterioration and help initiate interventions that prevent FTR [20-22,45]. In a study by Watkins et al, the nurses surveyed in the study agreed that continuous vital sign monitoring would help enhance patient safety. There are various technologies that can be used, with direct or not direct patient contact, or that delay the alarm set off, providing some time to deviations in vital signs to normalize to prevent alarm fatigue and distractions [21,22]. There are some barriers for the implementation of such technologies, as inadequate training or unfamiliarity with them, challenges in incorporating them into the clinical workflow, or budget restrictions, but there are also facilitators such as education to these systems, valuing how these technologies worked in the hospital they are being implemented in, tailoring them and integrating them into existing workflows and receiving regular feedback about progress [22]. There is still needed research in this area about which parameters should be captured, or if all patients should be monitored or specific types of patients [23].

There is evidence that incorporation of telemedicine ICU nurses in best practice initiatives in the ICU can reduce hospital length of stay and improve adherence to practices that avoid FTR. In order to further prevent FTR, it may be useful to clarify the tele-ICU nurse's role in order to prevent delays and support proactive clinical practice, and also further study their impact on patient outcomes [27].

Efferent limb

The efferent limb can be divided into 2 systems: ramp-up or ramp-down systems. In the ramp-up systems the magnitude of the initial response is linked with the severity of the patient's physiological deviation. The ramp-down systems mobilize maximum resources initially and then can de-escalate, once the triage of the patient and the situational needs are assessed [18].

Rapid response teams and medical emergency teams have become the standard approach to the efferent arm, becoming more prevalent in hospital systems overtime [19]. Their constitution may vary in different institutions, but they are typically multidisciplinary and comprise a critical care physician, a critical care nurse and a respiratory therapist at minimum [8,46]. Evidence also shows that intensivists used on rapid response teams are predictors of high performance and may improve FTR [8,10].

According to Fernandez-Moure et al, the medical emergency teams are more directed to a specific diagnosis, like cardiac arrest or stroke, and are arranged around those medical diagnoses, as opposed to the rapid response teams, that have to often respond to a medical emergency of unclear origin [60]. A surgical rescue team can also be important and has shown improved outcomes. Medical patients can also have emergent surgical pathology, that can have a mortality of 100% if they don't undergo surgery, so the concept of surgical rescue can be extended to those patients and acute care surgeons can be established as the surgical RRS for medical patients [11].

Cognitive aids aim to improve communication, teamwork and leadership and the surgical safety culture and accelerate escalation of care and optimize resuscitation by lowering omitted management steps, and therefore have potential to reduce FTR [48]. Despite the potential benefit in implementing this strategy to reduce FTR, there is still not a widespread use in clinical practice [48]. Implementation of crisis checklists also has the potential to improve patient outcomes by structuring the responses to clinical deterioration by the first responders

in the management of common emergencies while escalation to rapid response teams occur [14].

Key Learning Points

- Patient characteristics such as age, frailty, and comorbidities are risk factors for the occurrence of FTR, and increased surveillance to these patients, and prehabilitation programs for frail patients may help reduce the risk of FTR.
- Centralization of care may help reduce FTR, due to the relationship seen between hospital volume and FTR rates.
- Several hospital factors are related to FTR, however they may be difficult to change and improve. The focus on microsystem factors, although their contribution to FTR still needs further study, may be a more feasible way to improve patient outcomes, using strategies as team resource management training.
- Creation of clinical pathways and assigning the same group of patients consistently to nurses may help improve surveillance and recognition of clinical deterioration. Also, tools like SBAR can be used by nurses to improve communication.
- Aggregate weighted systems, such as NEWS and MEWS are the most reviewed and validated early warning scores and have been shown to have a positive relation with earlier detection of clinical deterioration, however they can lead to alarm fatigue and diversion of medical care from patients who might need it due to false alarms. The implementation of digital handheld devices for electronic charting with automatic calculation of scores and embedded alerts is associated with an increased accuracy and attendance to patients with high EWS scores.
- Machine learning systems have shown to outperform traditional EWS systems and may lead to a better early identification of patient deterioration, however they depend on the quality and quantity of data used to train them, and an errant system could harm a greater number of patients.
- Continuous monitoring of patients may also help improve early detection of clinical deterioration and initiation of interventions that prevent FTR.
- Rapid response teams and medical emergency teams have shown to have a positive relation with reduction of FTR and the use of intensivists in these teams may also improve FTR.
- Cognitive aids and use of crisis checklists also have potential to help reduce FTR, although their use is not widespread in clinical practice.

Conclusion

In conclusion, there are several strategies that may help prevent the occurrence of FTR.
Patient and hospital factors are many times hard to modify, therefore a focus on improving microsystem factors through team resource management training, simulation sessions and implementation of multidisciplinary safety programs may be a way of reducing FTR. Even so, additional investigation to the microsystem factors contribution for FTR would be interesting to further understand their importance.

Furthermore, the creation of clinical pathways and assignment of the same group of patients consistently to nurses may contribute to improve nursing surveillance and recognition of clinical deterioration, and the use of communication tools like SBAR may help relay information and improving confidence in managing emergent situations and calling for help.

Regarding track and trigger systems, there is contradictory information in the literature, and the amount of EWS makes it difficult to compare them and validate them. Nonetheless, aggregate weighted systems are the most reviewed and validated ones, despite their limitations. Howbeit, machine learning systems have shown to outperform EWS systems and could be a good strategy to prevent FTR. In that matter, studies to understand the best machine learning model and its applicability to different settings of care could be interesting.

Continuous monitoring could also be a strategy to improve patient outcomes by detecting early clinical deterioration, however there is still need for insight on which patients would benefit this type of monitoring and which parameters should be assessed.
In the efferent limb, rapid response teams have become the standard and have shown to help reduce FTR.

Finally, randomized trials to assess the benefits of cognitive aids and crisis checklists could also be important to assess their benefits and if they are proven, using them more widely in clinical practice in order to prevent and reduce FTR.

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